

# Management of corn silage and tomato residue silage through hydrothermal carbonization process

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Resort Sepetná,  
Ostravice, Czechia



AGH University of Krakow

# Agenda



Corn silage and tomato residue silage



Hydrothermal carbonization process (HTC)



Experiment conditions



Results

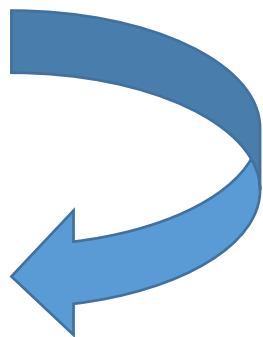
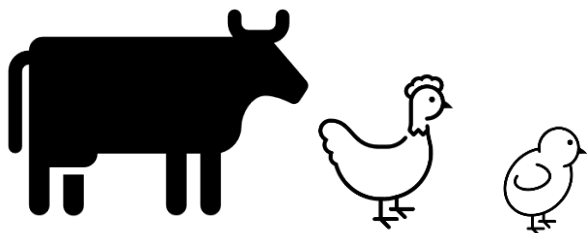


Conclusions

# Corn silage and tomato residue silage

**Silage** is produced from foliage crops undergoing the fermentation process until becomes sour.  
 Main source: grass plants, including corn, sorghum and other cereals.

Silage is used as a feed for livestock such as cattle and sheep



## Corn silage (CS):

- the estimated price per ton for 2025 is approx. \$63.



## Tomato residue silage (TRS):

- the estimated price per ton for 2025 is approx. \$115.

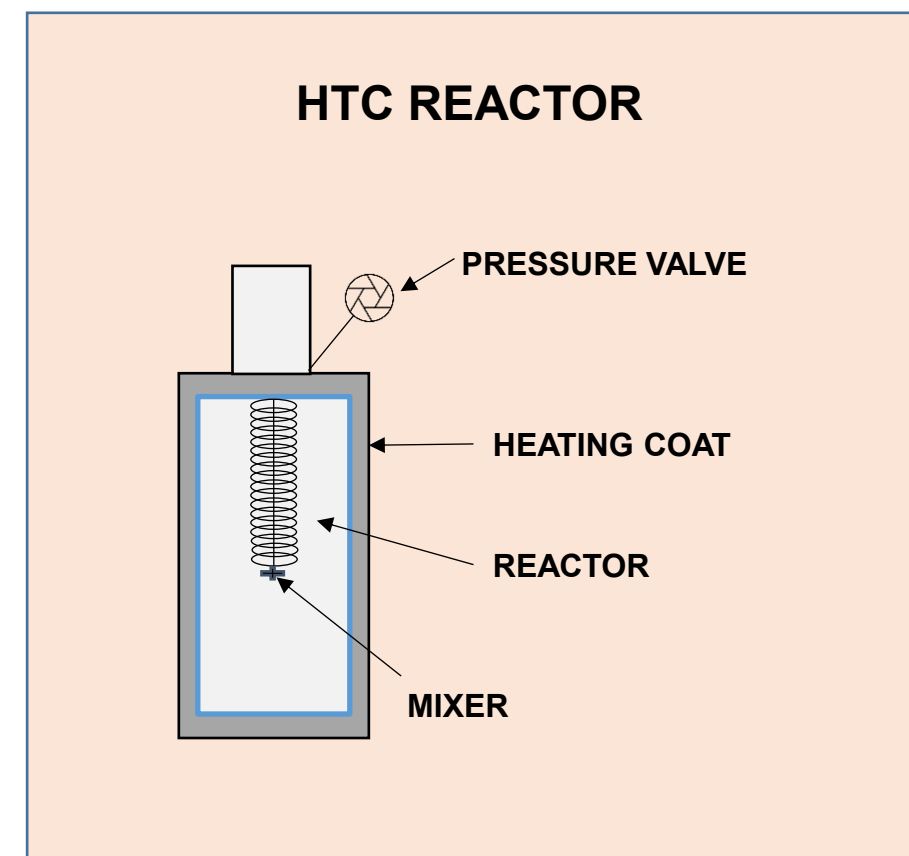


# Characteristic of hydrothermal carbonization process (HTC)

- Dedicated for biomass with a high moisture content
- Temperature range: 180 - 290°C
- Residence time: 0.5 - 8 h

➤ Hydrochar is a hydrophobic material rich in carbon characterized by low porosity

➤ Process water contains salts, sugar and aromatic organic compounds



# Experiment conditions

HTC set-up: a stainless steel ZipperClave® Stirred Reactor (Parker Autoclave Engineers)

## The HTC parameters:

- temperature: 190 °C and 210 °C
- residence time: 0.5 h and 2 h
- biomass to water ratio: 1:8

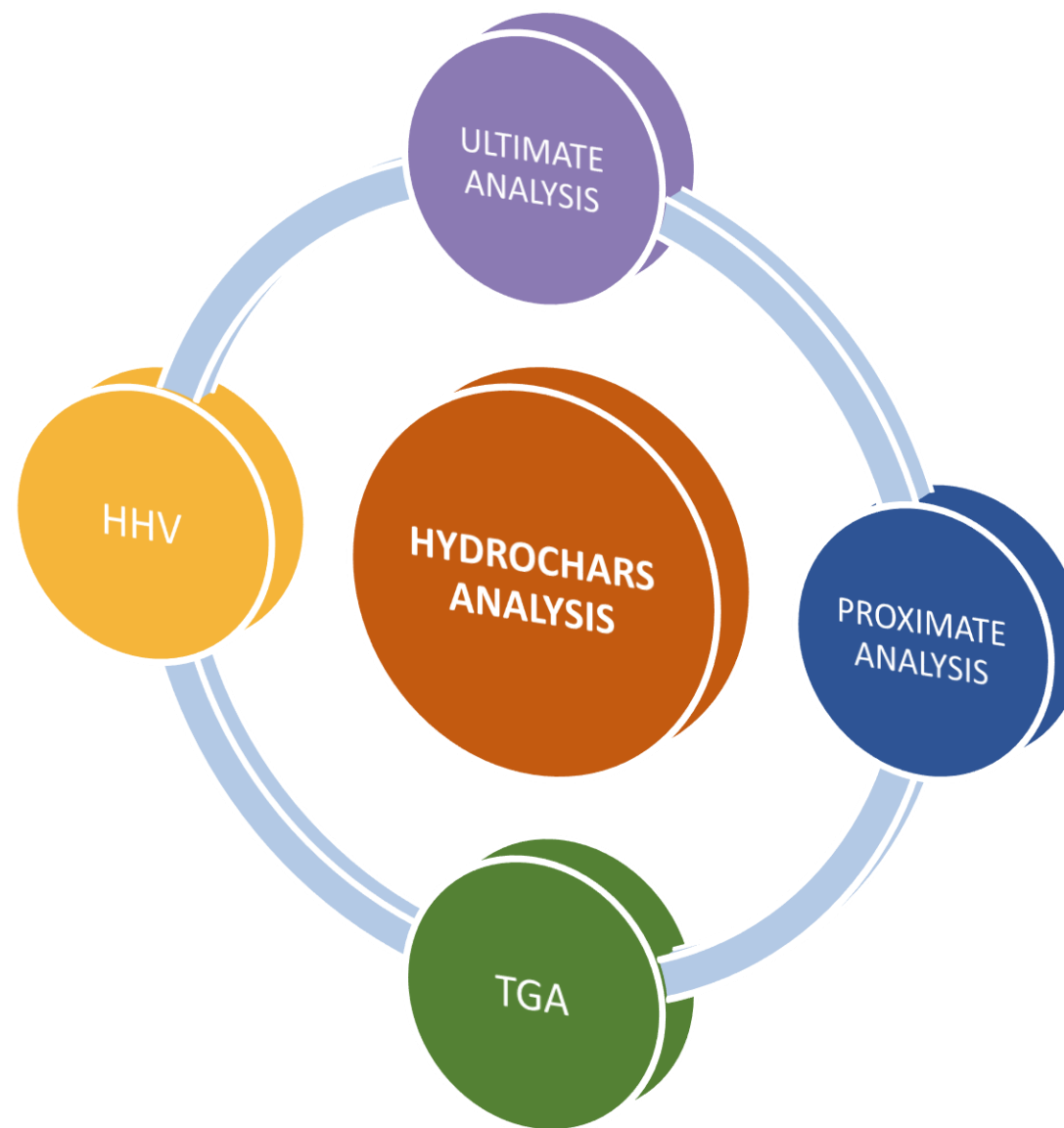


**Mixture of TRS+distilled  
water before HTC**



**Mixture of CS+distilled  
water before HTC**

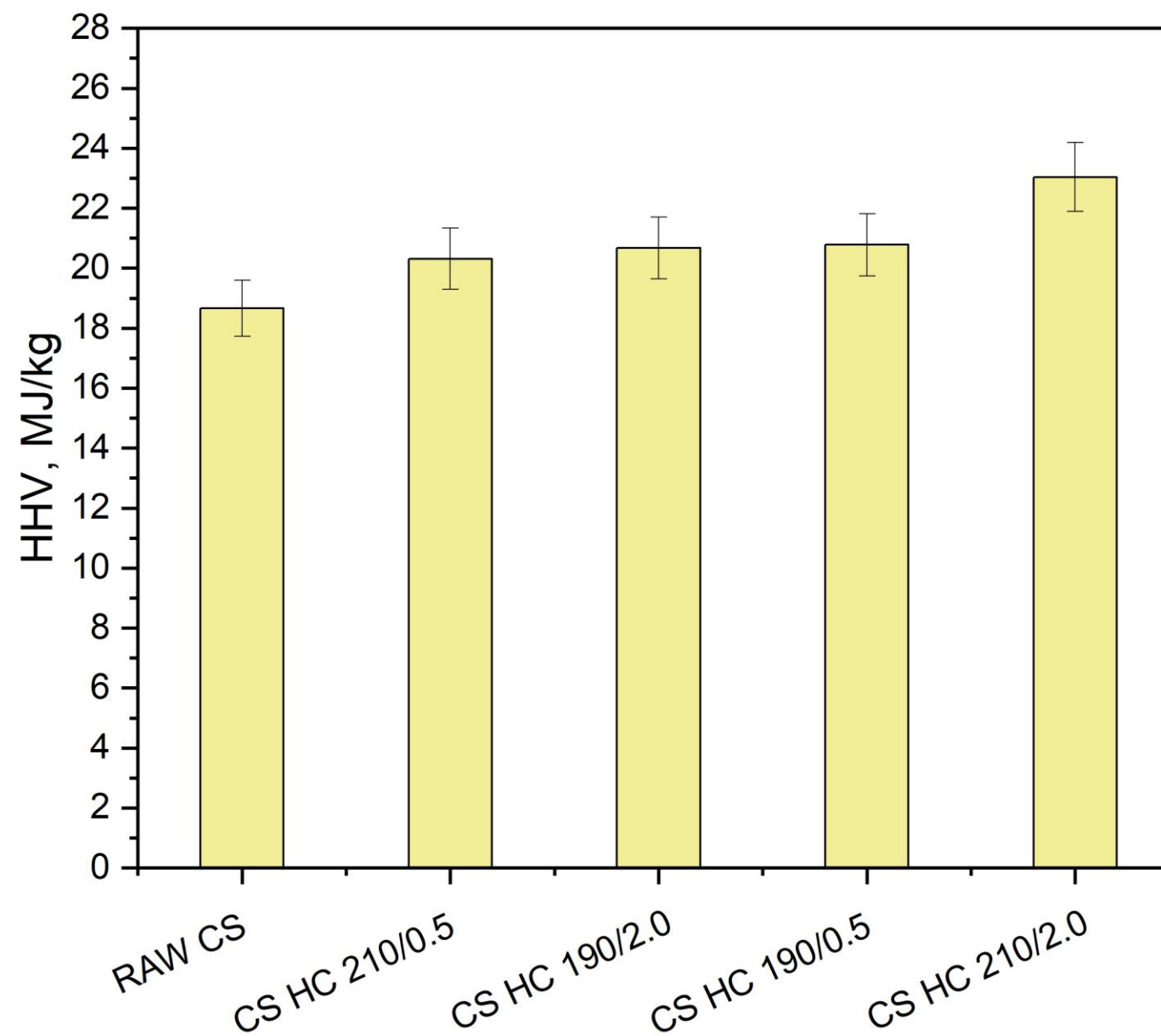
# RESULTS



## Ultimate analysis - CS

Name of sample	C, %	H, %	N, %	O, %
RAW CS	47.13	6.44	1.30	38.83
CS HC 190/0.5	51.85	6.42	1.67	33.47
CS HC 190/2.0	51.20	6.73	1.56	25.38
CS HC 210/0.5	50.45	6.79	1.49	26.20
CS HC 210/2.0	57.35 HIGH	6.34	1.69	26.41

# HHV results - CS



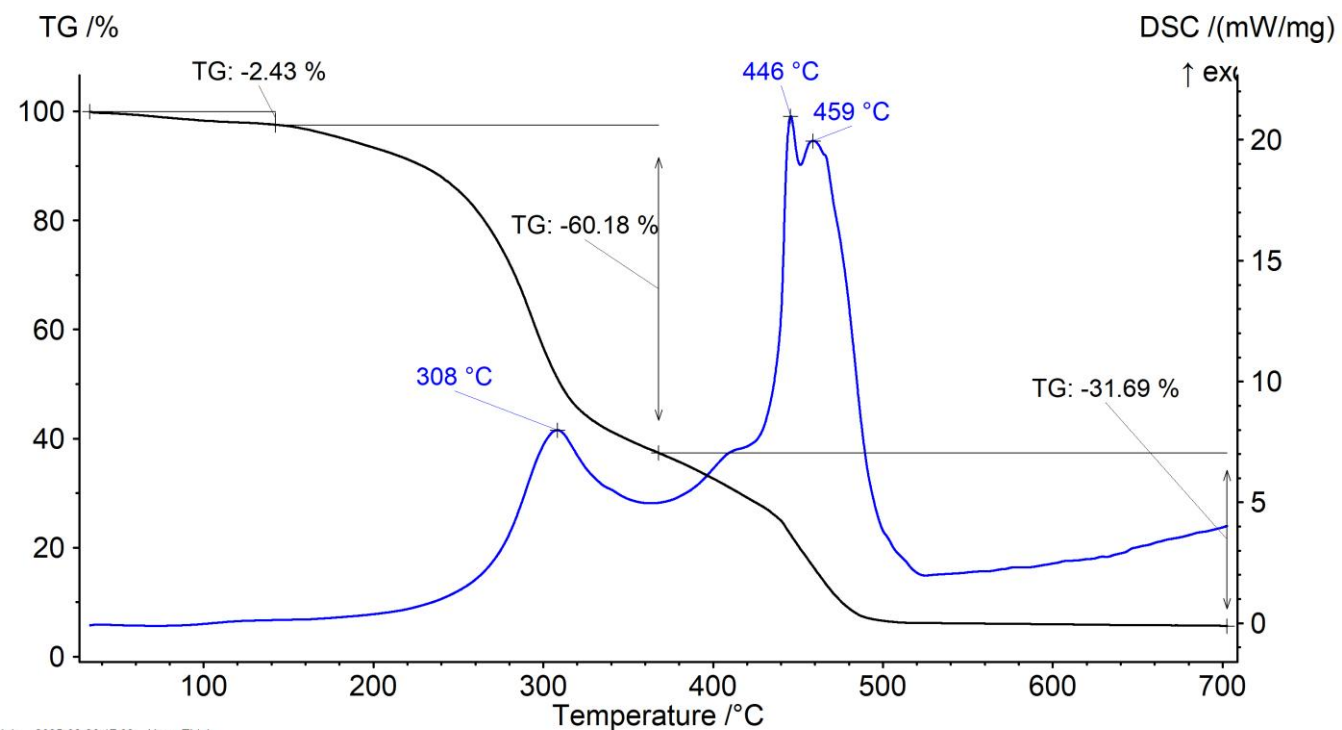


## Proximate analysis - CS

Name of sample	Moisture, %	Ash, %	Volatile matter, %
RAW CS	2.08	4.22	83.56
CS HC 190/0.5	3.75	2.84	79.24
CS HC 190/2.0	1.53	2.81	73.84
CS HC 210/0.5	12.16	2.92	67.65
CS HC 210/2.0	5.45	2.77	63.47

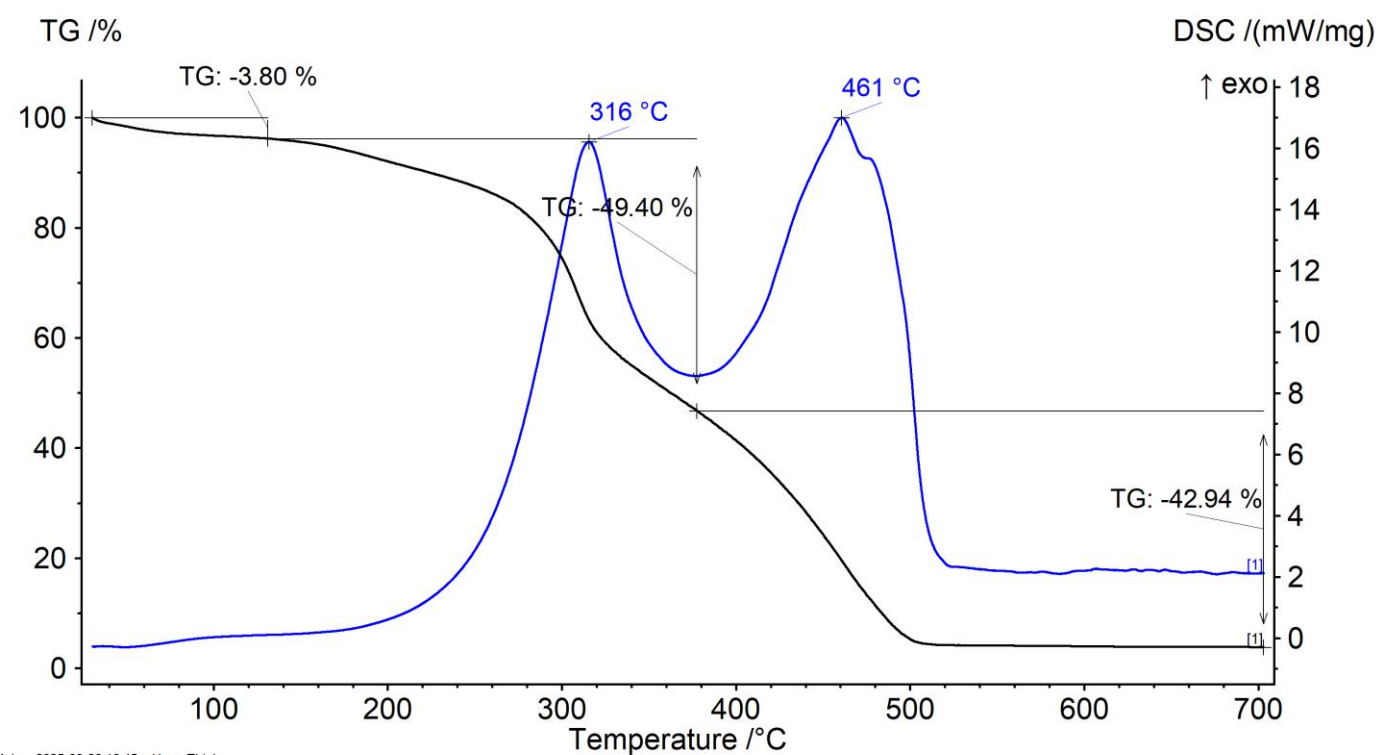
# TGA results - CS

TGA results – RAW CS



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TGA results – CS HC 210/2.0

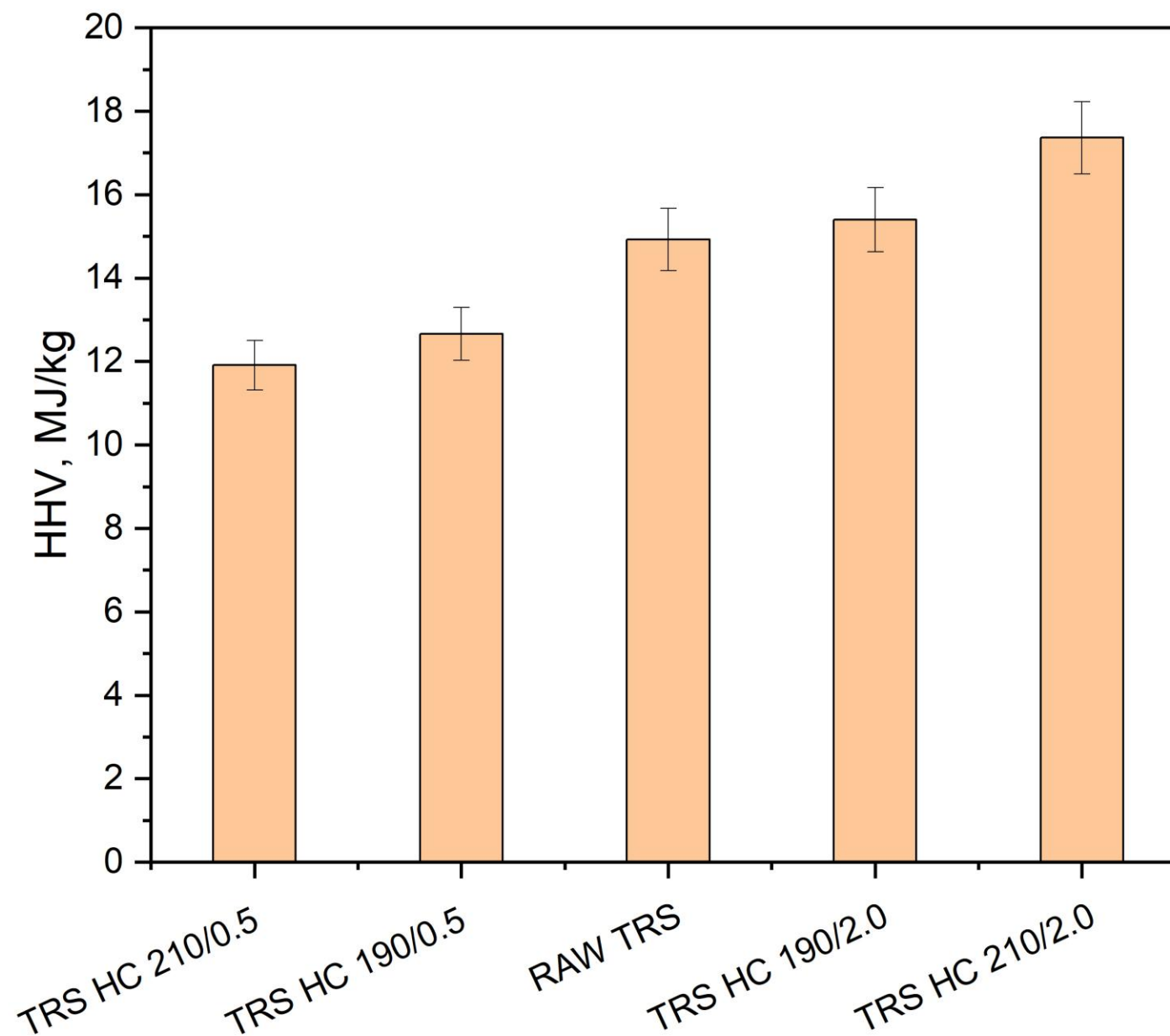


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# Ultimate analysis - TRS

Name of sample	C, %	H, %	N, %	O, %
RAW TRS	35.31	4.53	2.38	35.48
TRS HC 190/0.5	32.75	6.78	1.45	17.67
TRS HC 190/2.0	40.85 HIGH	5.89	1.86	24.13
TRS HC 210/0.5	29.25	7.23	1.34	7.86
TRS HC 210/2.0	40.40 HIGH	5.86	1.85	19.90

# HHV results - TRS

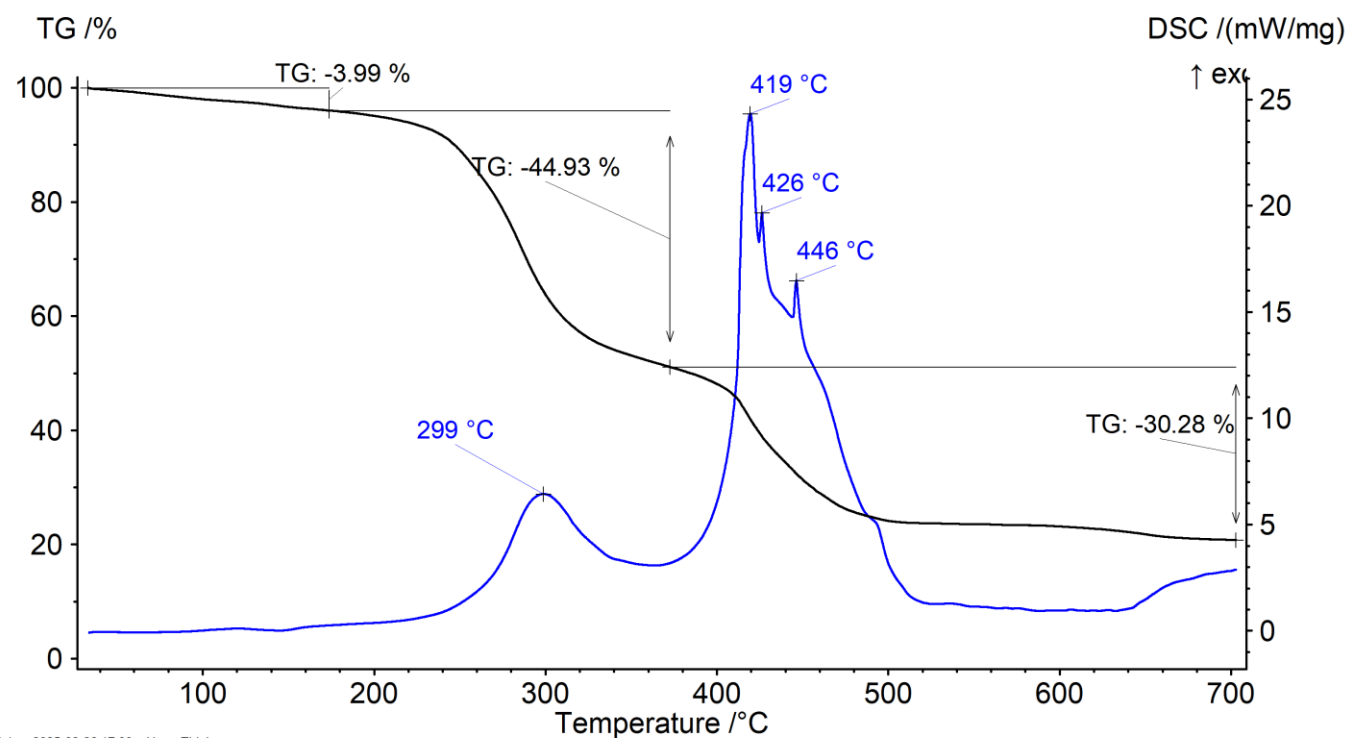


## Proximate analysis - TRS

Name of sample	Moisture, %	Ash, %	Volatile matter, %
RAW TRS	3.63	18.66	68.03
TRS HC 190/0.5	9.98	15.72	72.66
TRS HC 190/2.0	10.61	16.67	72.51
TRS HC 210/0.5	36.87	17.45	74.99
TRS HC 210/2.0	1.21	18.63	68.06

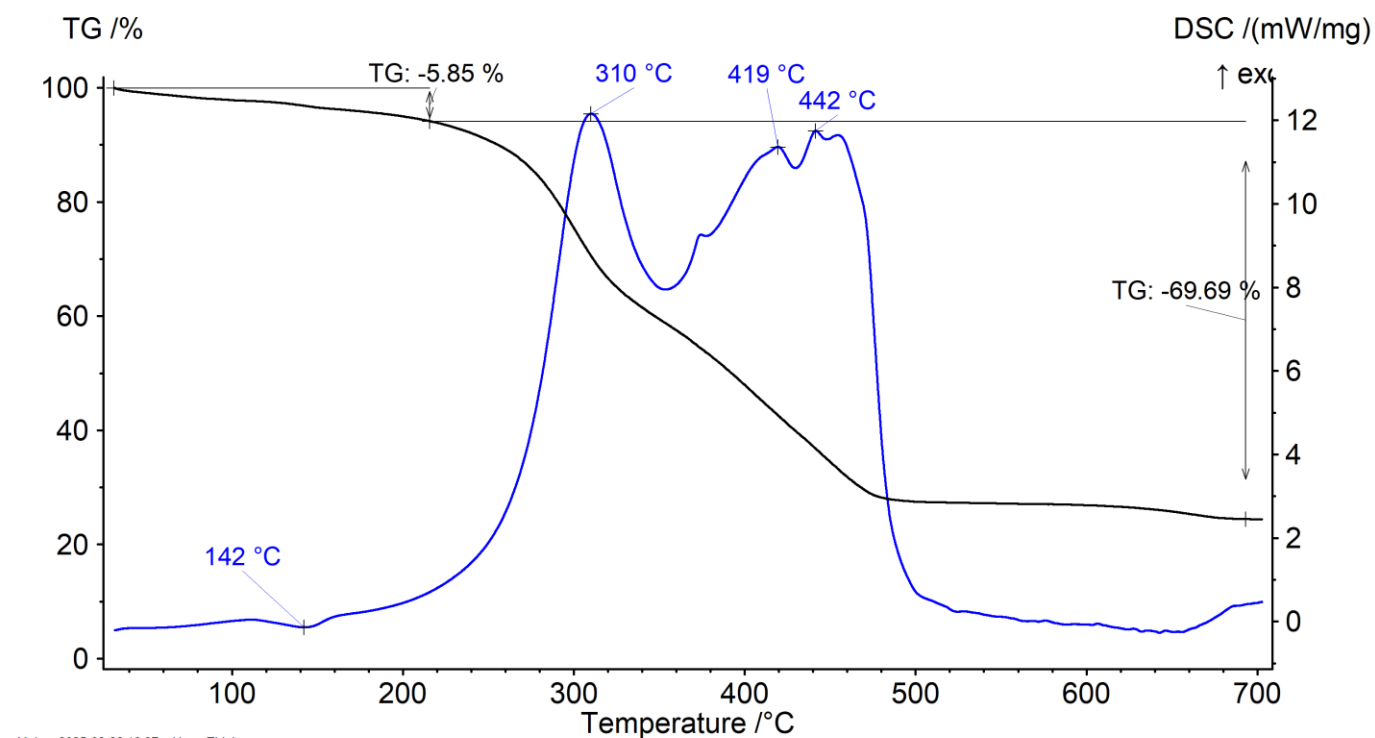
# TGA results - TRS

TGA results – RAW TRS



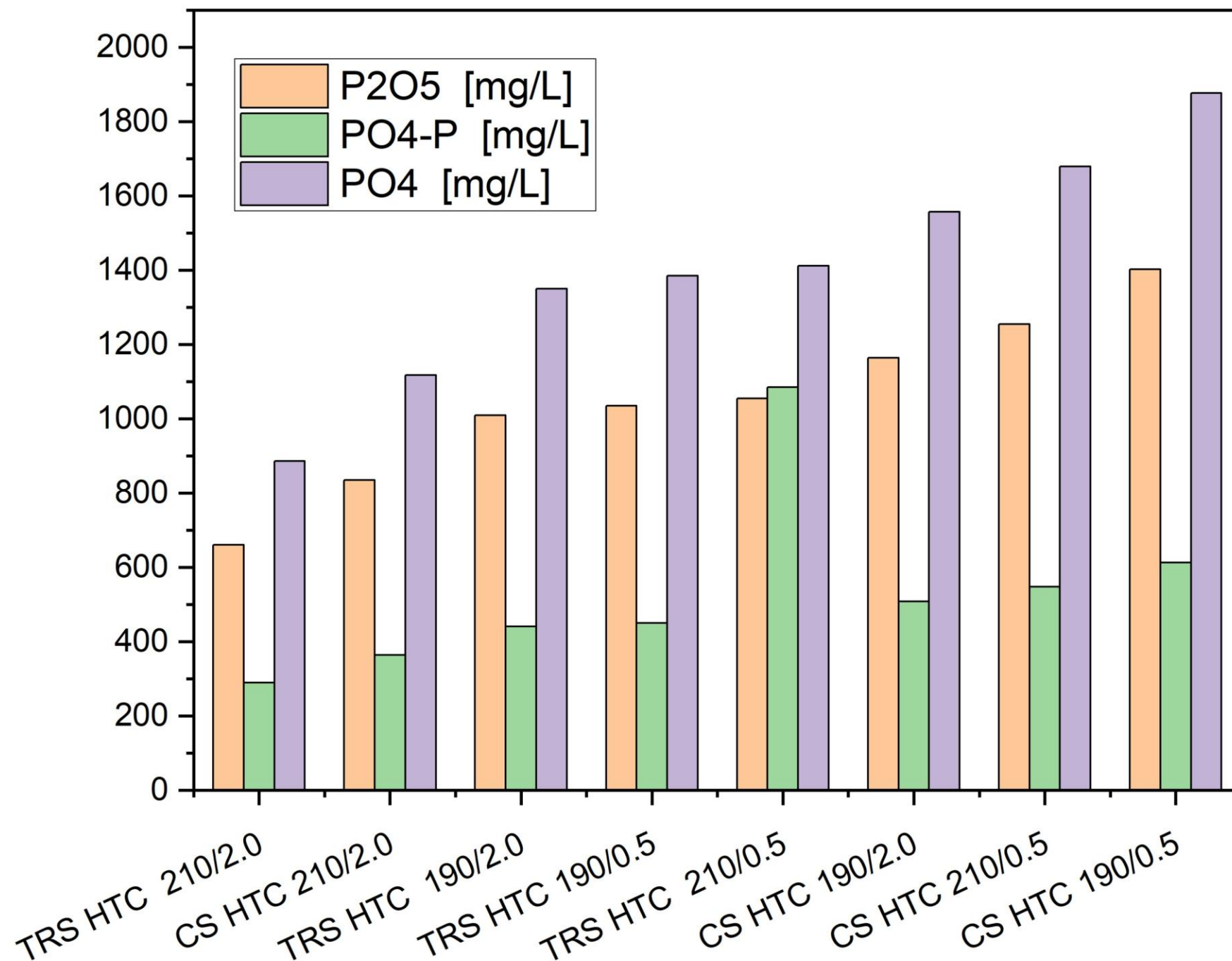
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TGA results – TRS HC 210/2.0

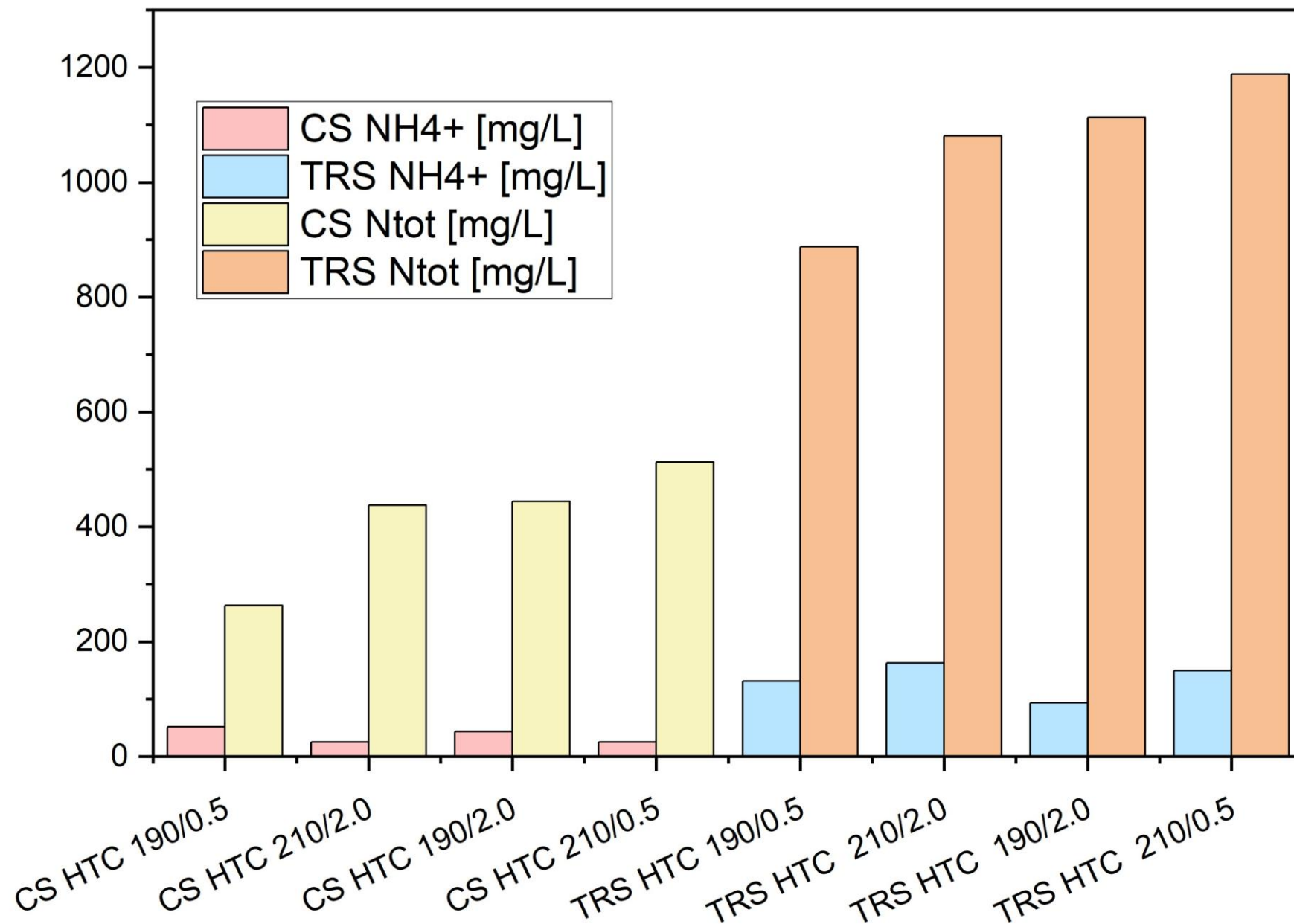


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# Process water results



# Process water results

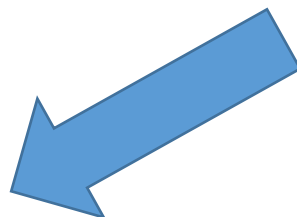




# Process water results

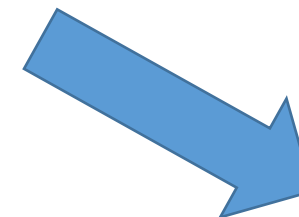
Name of sample	TOC [mg/L]	Phenol [mg/L]	COD [mg/L]
CS HTC 190/0.5	28237.5	322.75	86520
CS HTC 190/2.0	19525.0	254.75	82037
CS HTC 210/0.5	20312.5	293.00	73615
CS HTC 210/2.0	15500.0	287.25	42095
TRS HTC 190/0.5	15975.0	196.75	40607
TRS HTC 190/2.0	12475.0	248.25	36160
TRS HTC 210/0.5	12662.5	232.25	88980
TRS HTC 210/2.0	12375.0	277.25	89585

# Conclusions



## **Corn silage:**

- longer residence time in the reactor affects the higher carbon content in hydrochars.
- all hydrochars have better fuel properties than raw CS.



## **Tomato residue silage:**

- longer residence time influences the higher content of carbon in hydrochars.
- only hydrochars produced in residence time of 2 hours exhibits better fuel properties than raw TRS.



# Conclusions



## Process water:

- **CS** has a higher content of phosphorus compounds than **TRS**.
- A shorter residence time in the reactor results in a higher content of phosphorus compounds in both **CS** and **TRS**.
- **TRS** is characterized by a higher nitrogen content than **CS**.

**Hydrochar can be used in the heating sector as fuel or as a soil improver. Process water can be used as liquid fertilizer.**

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# Thank you!

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